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For **SWITCHING METHOD FOR BIDIRECTIONAL LINE SWITCHED RING AND NODE APPARATUS USED IN THE RING**

Enclosed are:

[X] 22 sheets of drawings.(Figs. 1-5,6A,6B,7-9,10A,10B,11-22)
[X] Specification, including claims and abstract (28 pages)
[X] Declaration
[X] An assignment of the Invention to FUJITSU LIMITED
[X] A certified copy of Japanese Application No(s). 11-371615
[X] An associate power of attorney
[ ] A verified statement to establish small entity status under 37 CFR 1.9 and 37 CFR 1.27
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BASIC FEE		
TOTAL CLAIMS	12-20 =	0
INDEP CLAIMS	2-3 =	0
[ ] MULTIPLE DEPENDENT CLAIMS PRESENTED		

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SMALL ENTITY	
RATE	FEE
	$355
x 9 =	$
X 40 =	$
x 135 =	$
TOTAL	$

OTHER THAN A SMALL ENTITY	
RATE	FEE
	$710
x 18 =	$
x 80 =	$
x 270 =	$
TOTAL	$710

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SPECIFICATION

TO ALL WHOM IT MAY CONCERN:

BE IT KNOWN THAT WE, Takashi Honda, a citizen of Japan residing at Kawasaki, Japan, Hiroshi Kanzawa, a citizen of Japan residing at Kawasaki, Japan and Junichi Moriyama, a citizen of Japan residing at Kawasaki, Japan have invented certain new and useful improvements in

SWITCHING METHOD FOR BIDIRECTIONAL LINE SWITCHED RING AND NODE APPARATUS USED IN THE RING

of which the following is a specification : -

TITLE OF THE INVENTION

SWITCHING METHOD FOR BIDIRECTIONAL LINE SWITCHED RING AND NODE APPARATUS USED IN THE RING

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a switching method for a BLSR (Bidirectional Line Switched Ring) and a node apparatus used in the ring, and, in particular, to a switching method for a four-fiber BLSR and a node apparatus used in a four-fiber BLSR.

2. Description of the Related Art

A BLSR is a ring network system in which one time slot in a line is used by a plurality of paths, and another time slot is had as a spare in common by the plurality of paths, and, thereby, high line holding efficiency can be achieved.

In a 4-fiber BLSR configuration, there are two methods of recovering from a fault condition on ring. A first method is span switch using a short path between nodes between which a fault exists. A second method is ring switch using a long path. When span switch could not be performed, ring switch using a long path is performed so that recovery from the fault condition is achieved.

According to BELLCORE standard GR-1230-CORE Issue 4, R6-151 for SONET (Synchronous Optical Network) BLSR equipment generic criteria, it is prescribed to perform ring switch by SF (Signal Fail) or SD (Signal Degrade) when a notice of reception cannot be received by a short path from an adjacent node within a predetermined time after span switch by serious SF (that is, SF-S) or span switch by slight SD (that is, SD-S) is performed.

FIG. 1 illustrates span switch.

In the figure, in a node A, when a fault in a working line Wba is detected, a span switch SS2a of the node A and a span bridge SB1b of a node B are switched from the working line Wba to a protection line Pba, and, also, a span bridge SB2a of the node A and a span switch SS1b of the node B are switched from a working line Wab to a protection line Pab. Thus, a span switch operation is performed.

FIG. 2 illustrates ring switch.

In FIG. 2, when a fault in the working line Wba and a protection line Pba is detected in the node A, a ring switch RS2a and a ring bridge RB1a of the node A are switched so that output from the node A to the working line Wab is connected to a protection line Paf, and, also, input from a protection line Pfa is connected to the working line Wba of the node A. Also, a ring switch RS1b and a ring bridge RB2b of the node B are switched so that input from a protection line Pcb is connected to input from the working line Wab of a node A, and output from the node B to the working line Wba is connected to a proportion line Pbc. Thus, a ring switch operation is performed.

It is assumed that a case occurs where upon occurrence of a fault, span switch cannot be performed and therefore ring switch is performed. Then, after that, even when recovery is made from the situation in which span switch cannot be performed, it is not possible to know this fact of recovery, and to know a time when a check should be made to determine whether or not the recovery is achieved.

Once ring switch is performed, recovery from the fault condition is achieved. Accordingly, it is not necessary to perform span switch, and it is not necessary to always make a check to determine

whether or not recovery is made from the situation in which span switch cannot be performed.

However, it is necessary to make a check to determine whether or not recovery is achieved from the situation in which span switch cannot be perform, when a fault occurs in another span, or switching will then be made by the reason why recovery is achieved from the situation in which span switch cannot be perform.

However, because a check operation for such a case is not prescribed, there may be an apparatus in which recovery can be made from a fault condition and an apparatus in which apparently recovery cannot be made from a fault condition, although recovery can actually be made in either apparatus. Accordingly, compatibility is degraded.

Further, during execution of ring switch, as a result of a lately made switching request having a high priority being performed, the contents of K1 and K2 bytes for transmitting/receiving a switching protocol, that is, APS (Automatic Protection Switch) information is not stabilized in the APS of overhead of SONET. Thereby, a switching operation is repeated, and an alarm of APS occurs.

SUMMARY OF THE INVENTION

The present invention has been made in consideration of the above-mentioned problems, and, an object of the present invention is to provide a switching method for a BLSR by which it is possible to stabilize APS information and switching operation.

According to the present invention, in a multi-fiber bidirectional line switched ring,

span switch is performed by one node of the ring for getting rid of a fault detected by the one node;

the span switch is changed into ring

switch when the span switch cannot be performed normally, and the ring switch is performed; and

the ring switch request is held as internal request of the one node when span switch request, higher in priority than the ring switch, generated in another node is received by the one node.

Thus, when the span switch request generated in the other node higher in the priority than the ring switch is received by the one node, the ring switch is held as the internal request of the one node, and check as to whether recovery is achieved from a situation in which span switch cannot be performed is not made. Accordingly, it is possible to stabilize APS information and switching operation.

When information indicating that the span switch request higher in the priority has come to be absent is received by the one node, restart may be made from span switch for getting rid of the fault detected by the one node.

Thus, when the information indicating that the span switch request higher in the priority has come to be absent is received by the own node, restart is made from span switch to get rid of the fault of the own node. Accordingly, it is possible to make check as to whether or not recovery is achieved from the situation in which span switch cannot be performed, at the time span switch higher in the priority has come to be absent.

Ring switch according to a new fault alarm level may be performed when the fault alarm level received by the one node is changed into the new fault alarm level while the ring switch is on performance.

Thus, when the fault alarm level detected by the own node changes into another one during

performance of ring switch, ring switch according to the other fault alarm level is performed, and switching between ring switch and span switch is not performed. Accordingly, it is possible to prevent useless switching operation from frequently occurring.

When, from another node adjacent on the side reverse to the side on which the ring switch is performed, ring switch request for the one node is received, the one node may be isolated from the ring.

Thus, when, from the node adjacent on the side reverse to the side on which the ring switch is performed, the ring switch request for the one node is received, the one node is isolated from the ring, and the ring switch is cancelled (a ring bridge and a ring switch are returned) by the one node. Accordingly, it is possible to stabilize APS information and switching operation.

When span switch request higher in the priority than the ring switch is received by the one node, the ring switch operation of the one node may be cancelled (a ring bridge and a ring switch may be returned), the received span switch request may be caused to pass through the one node so as to be transmitted to an adjacent node.

Thereby, it is possible to stabilize APS information and switching operation.

When span switch is attempted to be performed between the one node and each of adjacent nodes on both sides, but the span switch between the one node and the one adjacent node cannot be performed so as to be changed into ring switch, comparison of the priority between the span switch request for the other adjacent node and the ring switch request for the one adjacent node may be made by the one node so as to determine whether the span switch or ring switch is to be performed, and

request may be made to the adjacent nodes on both sides based on the result of the determination.

Thereby, it is possible to stabilize APS information and switching operation.

Other objects and further features of the present invention will become more apparent from the following detailed description when read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates span switch;

FIG. 2 illustrates ring switch;

FIG. 3 shows a configuration of ring network (BLSR) to which methods according to the present invention are applied;

FIG. 4 shows a block diagram of a node according to the present invention;

FIG. 5 shows an operation sequence in a first embodiment at a time of fault occurring between nodes A and B according to the present invention;

FIGS. 6A and 6B show lists of APS information in the first embodiment at a time of fault occurring between the nodes A and B according to the present invention;

FIG. 7 shows a flow chart performed by the node A at a time of fault occurring between the nodes A and B according to the present invention;

FIG. 8 shows the configuration shown in FIG. 3 but also having another line fault;

FIG. 9 shows an operation sequence in a second embodiment at a time of fault occurring between nodes C and D according to the present invention;

FIGS. 10A and 10B show lists of APS information in the second embodiment at a time of fault occurring between the nodes C and D according

to the present invention;

FIG. 11 shows a flow chart performed by the node A at a time of fault occurring between the nodes C and D during performance of ring switch between the nodes A and B according to the present invention;

FIG. 12 shows an operation sequence in a third embodiment at a time of fault occurring between the nodes A and B according to the present invention;

FIG. 13 shows a list of APS information in the third embodiment at a time of fault occurring between the nodes A and B according to the present invention;

FIG. 14 shows a flow chart performed by the node A at a time of occurrence of change in detection alarm during performance of ring switch between the nodes A and B according to the present invention

FIG. 15 shows the configuration shown in FIG. 3 but also having other line faults;

FIG. 16 shows an operation sequence in a fourth embodiment at a time of fault occurring between nodes A and F according to the present invention;

FIG. 17 shows a list of APS information in the fourth embodiment at a time of fault occurring between the nodes A and F according to the present invention;

FIG. 18 shows a flow chart performed by the node A at a time of fault occurring between the nodes A and F during performance of ring switch between the nodes A and B according to the present invention;

FIG. 19 shows the configuration shown in FIG. 3 but also having another line fault;

FIG. 20 shows an operation sequence in a

fifth embodiment at a time of fault occurring between the nodes A and F according to the present invention;

FIG. 21 shows a list of APS information in the fifth embodiment at a time of fault occurring between nodes A and F according to the present invention; and

FIG. 22 shows a flow chart performed by the node A at a time of fault occurring between the nodes A and F during performance of ring switch between the nodes A and B according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 3 shows a configuration diagram of a ring network (BLSR) to which the present invention is applied.

As shown in the figure, six nodes A, B, C, D, E and F are connected to form a ring by optical fibers shown by arrows of solid lines and broken lines. The arrows express information transmission directions. The solid lines represent working lines while broken lines represent protection lines.

In this configuration, there are two possible paths from the node A to the node B, i.e., a short path from the node A to the node B directly and a long path from the node A to the node A via the nodes F, E, D and C passed through in the stated order.

FIG. 4 shows a block diagram of a node in any embodiment of the present invention which will be described later. For example, description will be made assuming that the node shown in FIG. 4 is the node A shown in FIG. 3.

In FIG. 4, a fault detecting part 20 detects a fault in each of the working line Wfa and protection line Pfa, and supplies the detection

result to a switching control part 28.

A reception K byte reading part 22 reads APS information from a time slot received from each of the working line Wfa and protection line Pfa and supplies the thus-read information to the switching control part 28.

In an ordinary condition in which no fault occurs, through control by the switching control part 28, each of ring switch RS1a, span switch SS1a, span bridge SB2a and ring bridge RB2a is made to enter a condition in which a terminal 'a' is selected.

The time slot received from the working line Wfa passes through the ring switch RS1a, span switch SS1a and span bridge SB2a, is supplied to a transmission K byte writing part 24 and a terminal 'b' of a ring bridge RB1a, and, in the transmission K byte writing part 24, has APS information supplied from the switching control part 28 written thereto, and is sent out to a working line Wab.

The time slot received from the protection line Pfa passes through the ring bridge RB2a and is supplied to the transmission K byte writing part 24, and, also, is supplied to terminals 'b' of the span switch SS1a, span bridge SB2a and a ring switch RS2a, and, in the transmission K byte writing part 24, has APS information supplied from the switching control part 28 written thereto, and is sent out to a protection line Pab.

A fault detecting part 30 detects a fault in each of a working line Wba and a protection line Pba, and supplies the detection result to the switching control part 28.

A received K byte reading part 32 reads APS information from a time slot received from each of the working line Wba and protection line Pba, and supplies the thus-read information to the switching

control part 28.

In an ordinary condition in which no fault occurs, through control by the switching control part 28, each of ring switch RS2a, span switch SS2a, span bridge SB1a and ring bridge RB1a is made to enter a condition in which a terminal 'a' is selected.

The time slot received from the working line Wba passes through the ring switch RS2a, span switch SS2a and span bridge SB1a, is supplied to a transmission K byte writing part 34 and a terminal 'b' of the ring bridge RB2a, and, in the transmission K byte writing part 34, has APS information supplied from the switching control part 28 written thereto, and is sent out to a working line Waf.

The time slot received from the protection line Pba passes through the ring bridge RB1a and is supplied to the transmission K byte writing part 34, and, also, is supplied to terminals 'b' of the span switch SS2a, span bridge SB1a and ring switch RS1a, and, in the transmission K byte writing part 34, has APS information supplied from the switching control part 28 written thereto, and is sent out to a protection line Paf.

At a time span switch is performed, through control by the switching control part 28, for example, each of the span switch SS1a and span bridge SB1a is made to enter a condition in which the terminal 'b' is selected. Thereby, a time slot received from the protection line Pfa passes through the span switch SS1a and span bridge SB2a and is sent out to the working line Wab, while a time slot received from the working line Wba passes through the ring switch RS2a, span switch SS2a, span bridge SB1a and ring bridge RB1a, and is sent out to the protection line Paf.

At a time ring switch is performed, through control by the switching control part 28, for example, each of the ring switch RS2a and ring bridge RB1a is made to be in a condition in which the terminal 'b' is selected. Thereby, a time slot received from the protection line Pfa passes through the ring switch RS2a, the span switch SS2a and span bridge SB1a and is sent out to the working line Waf, while a time slot received from the working line Wfa passes through the ring switch RS1a, span switch SS1a, span bridge SB2a and ring bridge RB1a, and is sent out to the protection line Paf.

It is noted that priority of switching request is, from the higher one to the lower one, span switch by SF (SF-S), ring switch by SF (SF-R), span switch by SD (SD-S) and ring switch by SD (SD-R).

FIG. 5 shows an operation sequence in a first embodiment at a time a fault occurs between the nodes A and B according to the present invention. FIGS. 6A and 6B show lists of APS information at the time.

It is assumed that no fault exists in the ring as an initial condition. FIG. 6A shows the APS information at this time.

In FIGS. 6A and 6B, the first column indicates a symbol specifying APS information. K1 byte, first through fourth bits of the second column indicate switching request, but 'NR' represents 'no request'. K1 byte, fifth through eighth bits of the third column indicate a transmission destination of the APS information. K2 byte, first through fourth bits of the fourth column indicate a transmission source of the APS information. K2 byte, fifth bit of the fifth column indicates short span by the value '0' and long span by the value '1'. K2 byte, sixth through eighth bits of the sixth column

indicate a status of the transmission source.

Then, it is assumed that a serious fault occurs in the working line Wba between the nodes A and B as indicated by 'X' in FIG. 3. Then, at the time T1 shown in FIG. 5, the node A detects SF (Signal Fail) in the working line from the node B. Then, the node A transmits to the adjacent nodes B and F, APS information a3 and a4 (shown in FIG. 6B) of span switch by SF (SF-S) for the node B.

In response thereto, the node B returns APS information b2 of 'NR' shown in FIG. 6A, and there is no change in the APS information received by the node A. That is, the node A receives neither a response (RR-R) to the span switch nor another switching request from the node B. The reason why no response is made to the span switch is that a fault exists in the protection line Pba between the nodes A and B, or the span switch cannot be performed due to an internal condition of the node B, or the like.

Then, while there is no change in the situation, a predetermined time has elapsed after the node A transmitted SF-S, and the time T2 is reached. Thereby, the node A determines that performance of the span switch (SF-S) with the node B is not possible, transmits APS information a5 and a6 shown in FIG. 6B, and performs ring switch by SF (SF-R).

At this time, according to ordinary switching sequence, the request of the APS information a6 is caused to pass through the nodes F, E, D and C, and reaches the node B.

When the node B receives the APS information a6, the node B performs ring switch (operates the ring bridge and ring switch). Thus, the working line Wba from the node B to the node A is switched to be connected to the protection line

Pbc from the node B to the node C. Then, the node B transmits APS information b5 and b6 of response shown in FIG. 6B for the node A.

Further, when the node A receives the APS information b5 of response from the node B via the node F through the long span, the node A performs ring switch (operates the ring bridge and ring switch), and transmits APS information a7 and a8 of response.

The above-described operation is an ordinary one described in the standard GR-1230-CORE, Issue 4.

FIG. 7 shows a flow chart of a process which the node A performs when a fault occurs between the nodes A and B.

In FIG. 7, in a step S10, the node A determines whether or not SF is detected in the working line from the node B. When SF is detected, a step S12 is performed, and the node A requests span switch by SF (SF-S) of the node B.

Then, in a step S14, the node A determines whether or not a predetermined time has elapsed without response given from the node B. When the predetermined time has elapsed, a step S16 is performed. In the step S16, the node A requests ring switch by SF (SF-R) of the node B, and achieves the ring switch between the nodes A and B in a step S18.

Then, it is assumed that a serious fault then also occurs between the nodes C and D indicated by 'X' in the working line Wcd as shown in FIG. 8. FIG. 9 shows an operation sequence in a second embodiment performed when the fault occurs between the nodes C and D according to the present invention. FIGS. 10A and 10C show lists of APS information in this case.

At the time T3 shown in FIG. 9, the node D

detects SF in the working line from the node C. Then, the node D transmits APS information d3 and d4 (shown in FIG. 10A) of span switch by SF (SF-S) for the node C to the adjacent nodes C and E. In response thereto, the node C performs span switch (operates the span bridge), and transmits APS information c3 of response RR-S and APS information c4 of span switch by SF (SF-S) shown in FIG. 10A.

Further, when receiving the APS information c3, the node D performs span switch (operates the ring bridge and ring switch), and transmits APS information d5 and d6 of span switch by SF (SF-S) shown in FIG. 10A. When receiving the APS information d6 of span switch (SF-S), the node C performs span switch, and transmits APS information c5 of response RR-S and APS information c6 of span switch by SF (SF-S).

Further, when receiving the APS information d3 (or c4) of SF-S request from the node D to node C through long path while performing the ring switch (SF-R), the node A cancels the ring switch (returns the ring bridge and ring switch) because SF-R is lower than SF-S in the priority.

Then, the node A causes the received APS information d3 (or c4) of SF-S request to pass therethrough. However, the node A holds SF-R as internal request thereof.

Similarly, the node B cancels the ring switch (returns the ring bridge and ring switch) when receiving the APS information c4 (or d3) of SF-S request through long path from the node C to node D.

When the node D detects no SF in the working line from the node C and enters a waiting condition WTR at the time T4 shown in FIG. 9, the node D transmits APS information d7 and d8 (shown in FIG. 10A) of waiting WTR for the node C to the

adjacent nodes C and E, respectively.

The node C receives the APS information d8, and transmits APS information c7 of response RR-S and APS information c8 of waiting condition WTR shown in FIG. 10B for the node D.

The node A, while detecting that SF exists in the working line from the node B, receives the APS information d7 of waiting WTR transmitted from the node D for the node C, determines that the condition is such that request of the own node can be performed, and performs span switch (SF-S).

Although the request held in the node A as the internal request is SF-R, the node A restarts from span switch (SF-S) which can be performed at the present situation because the fault in the other location is already got rid of.

Then, the node A transmits APS information a9 and a10 of span switch (SF-S) shown in FIG. 10B. In response thereto, the node B transmits APS information b7 and b8 of no request NR shown in FIG. 10B to the nodes C and A.

FIG. 11 shows a flow chart of a process performed by the node A when a fault occurs between the nodes C and D during performance of ring switch between the nodes A and B.

In FIG. 11, in a step S20, the node A determines whether or not APS information of request for another node (for example, SF-S from the node C for the node D) higher in the priority than request of ring switch (SF-R) which is performed by the own node is received.

When the APS information of the above-mentioned request is received, the node A cancels the ring switch (SF-R) in a step S22, and causes the received APS information of the request to pass therethrough in a step S24.

However, the fact that the ring switch

(SF-R) was performed by the own node is held in the step S22.

Then, in a step S26, the node A determines whether or not APS information (for example, waiting WTR from the node D for the node C) for canceling request (for example, SF-S from the node C for the node D) which previously results in cancellation of the ring switch (SF-R) is received.

When this is received, a step S28 is performed, and the node A performs span switch (SF-S) for dealing with the situation in which the serious SF exists between the nodes A and B although the fact that the ring switch (SF-R) was performed by the own node is held.

Thus, when span switch request generated in another node higher in the priority than ring switch is received by the own node, the ring switch request is held as internal request of the own node, and a check as to whether or not recovery is achieved from the situation in which span switch cannot be performed is not made. Accordingly, it is possible to stabilize APS information and switching operation.

Further, when information indicating that span switch request higher in the priority has come to be absent is received by the own node, restart is made from span switch for getting rid of the fault of the own node. Accordingly, it is possible to make a check as to whether or not recovery is achieved from the situation in which span switch cannot be performed at the time span switch higher in the priority has come to be absent. Thereby, it is possible to achieve recovery from many faults.

Further, when span switch request higher in the priority is received by the own node, the ring switch operation of the own node is cancelled (the ring bridge and ring switch are returned), and

the received span switch request is passed through the own node and is transmitted to adjacent node. Accordingly, it is possible to stabilize APS information and a switching operation.

FIG. 12 shows an operation sequence performed when a fault occurs between the nodes A and B in a third embodiment of the present invention. FIG. 13 shows a list of APS information in this case. In the third embodiment, a detection alarm level of the working line Wba of the node A changes from serious SF into slight SD.

The node A transmits APS information a9 and a10 of span switch (SF-S), then a predetermined time has elapsed, and, then, the time T5 is reached shown in FIG. 12. When neither APS information of response RR-S to SF-S from the node B nor other span switch request has been received until the predetermined time has elapsed, ring switch is performed in the operation same as that of the case where the time T2 is reached shown in FIG. 5.

That is, the node A determines that span switch (SF-S) with the node B is not possible of performance, transmits APS information a5 and a6 shown in FIG. 6B, and performs ring switch by SF (SF-R). At this time, in the ordinary switching sequence, the request of APS information a6 is caused to pass through the nodes F, E, D and C, and reaches the node B.

When the node B receives this APS information a6, the node B performs ring switch (operates the ring bridge and ring switch), and switches the working line Wcb from the node C toward the node B to connect it to the protection line Pbc from the node D toward the node C. Then, the node B transmits APS information b5 and b6 of response shown in FIG. 6B for the node A.

When the node A receives the APS

information b5 of response from the node B via the node F through long span, the node A performs ring switch (operates thew ring bridge and ring switch), and transmits APS information a7 and a8 of response thereto.

Then, at the time T6, when the detection alarm level of working line Wba from the node B in the node A changes from serious SF to slight SD, the node A continues the ring switch on performance, changes the switching request into SD-R, transmits APS information a11 and a12 of switching request shown in FIG. 13 and thus transmits ring switch by SD (SD-R).

When receiving the APS information a11 from the node A, the node B performs ring switch by SD (SD-R), and transmits APS information b9 of switching request and APS information b10 of response RR-R shown in FIG. 13, to the nodes C and A, respectively.

FIG. 14 shows a flow chart of a process performed by the node A when detection alarm changes during performance of ring switch between the nodes A and B.

In FIG. 14, in a step S30, when the node A detects that the detection alarm level of the working line Wba from the node B changes from serious SF to slight SD, the node A continues the ring switch in a step S32.

In a step S34, the node A transmits APS information a11 and a12 of ring switch (SD-R) to the nodes B and F. In a step S36, the node A receives APS information b10 of response RR-R, and performs ring switch by SD (SD-R) between the nodes A and B.

Thus, when the fault alarm level detected by the own node changes during performance of ring switch, ring switch according to the fault alarm level after the change is performed, and switching

between ring switch and span switch is not performed. Accordingly, it is possible to prevent useless switching operation from frequently occurring.

A case where, in the condition in which the serous fault exists between the nodes A and B in the working line Wba shown in FIG. 3, a serious fault occurs in the working line Waf and protection line Paf between the nodes A and F indicated by 'X' in FIG. 15 will now be described. FIG. 16 shows an operation sequence in a fourth embodiment performed when a fault occur in the nodes A and F according to the present invention. FIG. 17 shows a list of APS information in this case.

The process from the time T5 to the time T7 in FIG. 16 is the same as the process from the time T5 to the time T6 in FIG. 12, and the list of APS information in this time is the same as those of FIGS. 6A and 6B.

When the time T7 is reached in FIG. 16, the node F detects a serious fault SF in the working line Waf and protection line Paf from the node A. Thereby, the node F performs ring switch (operates the ring bridge and ring switch), and transmits APS information f3 and f4 of ring switch (SF-R) shown in FIG. 17.

When receiving the APS information f3 of ring switch (SF-R), the node A cancels ring switch (returns the ring bridge and ring switch), and changes into an isolated condition. Then, the node A transmits APS information a11 and a12 of ring switch (SF-R) to the nodes B and F, respectively.

FIG. 18 shows a flow chart of a process performed by the node A when a fault occurs between the nodes A and F during performance of ring switch between the nodes A and B.

In FIG. 18, in a step S40, the node A receives APS information f3 of ring switch (SF-R)

from the node F. Thereby, in a step S42, the node A cancels ring switch (returns the ring bridge and ring switch), and enters an isolated condition in a step S44.

A case where a serious fault occurs in the working line Wba between the nodes A and B, and, then, a serious fault also occurs in the working line Waf between the nodes A and F shown in FIG. 19 by 'X' will now be described.

FIG. 20 shows an operation sequence in a fifth embodiment performed when a fault occurs between the nodes A and F. FIG. 21 shows a list of APS information thereof.

At the time T8 in FIG. 20, the node A detects a serious fault SF in the working line Wba from the node B, performs span switch (SF-S), and transmits APS information a3 and a4 of span switch (SF-S) request shown in FIG. 6B to the adjacent nodes B and F. However, the node A receives APS information b2 of 'NR' shown in FIG. 6A, and does not receive response to reception of the span switch (SF-S) request.

Then, the time T9 is reached, the node F detects a serious fault SF in the working line Waf from the node A, performs span switch (SF-S), and transmits APS information f5 and f6 of span switch (SF-S) request shown in FIG. 21 to the adjacent nodes A and E.

When receiving the APS information f5, the node A performs span switch (operates the span bridge), and transmits APS information a13 of span switch (SF-S) request and APS information a14 of span switch (SF-S) response to the nodes B and F.

As a result of receiving the APS information a14 of span switch (SF-S) response from the node A, the node F performs span switch (operates the span bridge and span switch), and

transmits APS information f7 and f8 of span switch (SF-S) request shown in FIG. 21 to the nodes A and E.

Then, when the time T10 is reached, the node A understands that span switch which the node A attempts to perform between the nodes A and B cannot be performed, and attempts to perform ring switch (SF-R).

However, because the APS information f7 of span switch (SF-S) request higher in the priority is received from the node F, the node A transmits APS information a15 of span switch (SF-S) request and APS information a16 of span switch (SF-S) response of the side of the node F to the nodes B and F.

FIG. 22 shows a flow chart of a process performed by the node A when a fault occurs between the nodes A and F while ring switch is on performance between the nodes A and B.

In FIG. 22, in a step S50, the node A receives APS information f5 of span switch (SF-S) from the node F. Thereby, the node A performs span switch (operates the span bridge) in a step S52, and transmits APS information a13 of span switch (SF-S) and APS information a14 of response to the nodes B and F in a step S54.

Then, in a step S56, the node A determines whether a predetermined time has elapsed without response to span switch given by the node B. When the predetermined time has elapsed, a step S58 is performed.

In the step S58, because APS information f7 of span switch (SF-S) request higher in the priority than ring switch (SF-R) which the node A attempts to perform is received from the node F, the node A transmits APS information a15 of span switch (SF-S) request and APS information a16 of span switch (SF-S) response of the side of the node F to the nodes B and F.

Thus, when span switch between the own node and the adjacent node on one side cannot be performed, and is changed into ring switch, the own node compares the priority between the ring switch request for the node on the one side and span switch request for the node on the other side.

Then, the own node determines whether the ring switch or span switch is to be performed, and information is transmitted to the nodes on both sides based on the determination.

Accordingly, it is possible to stabilize APS information and switching operation.

The present invention is not limited to the above-described embodiments, and variations and modifications may be made without departing from the scope of the present invention.

The present application is based on Japanese priority application No. 11-371615, filed on December 27, 1999, the entire contents of which are hereby incorporated by reference.

WHAT IS CLAIMED IS

1. A switching method for a multi-fiber bidirectional line switched ring comprising the steps of:

a) performing span switch by one node of said ring for getting rid of a fault detected by said one node;

b) changing the span switch into ring switch when the span switch can not be performed normally, and performing the ring switch; and

c) holding the ring switch request as internal request of said one node when span switch request, higher in priority than the ring switch, generated in another node is received by said one node.

2. The switching method as claimed in claim 1, further comprising the step of:

d) when information indicating that the span switch request higher in the priority has come to be absent is received by the one node, restarting from span switch for getting rid of the fault detected by said one node.

3. The switching method as claimed in claim 1, further comprising the step of:

d) when a fault alarm level received by

the one node is changed during performance of the ring switch, performing ring switch according to a new fault alarm level.

4. The switching method as claimed in claim 1, further comprising the step of:

d) when, from another node adjacent on a side reverse to a side on which the ring switch is performed, ring switch request for the one node is received, isolating said one node from the ring.

5. The switching method as claimed in claim 1, further comprising the step of:

d) when span switch request higher in the priority than the ring switch is received by the one node, canceling the ring switch operation of said one node, causing the received span switch request to pass through said one node so as to be transmitted to an adjacent node.

6. The switching method as claimed in claim 1, further comprising the step of:

d) when span switch is attempted to be performed between the one node and each of adjacent nodes on both sides, but the span switch between said one node and the one adjacent node on one side cannot be performed so as to be changed into ring switch, comparing by said one node the priority

between the span switch request for the other adjacent node and the ring switch request for said one adjacent node so as to determine whether the span switch or ring switch is to be performed, and sending request to the adjacent nodes on both sides based on the result of the determination.

7. A node apparatus used in a four-fiber bidirectional line switched ring comprising:

a part performing span switch for getting rid of a fault detected by said one node apparatus;

a part changing the span switch into ring switch when the span switch cannot be performed normally, and performing the ring switch; and

a part holding the ring switch request as internal request of said node apparatus when span switch request, higher in priority than the ring switch, generated in another node apparatus is received.

8. The node apparatus as claimed in claim 7, further comprising:

a part, when information indicating that the span switch request higher in the priority has come to be absent is received, restarting from span switch for getting rid of the detected fault.

9. The node apparatus as claimed in claim

7, further comprising:

a part, when a received fault alarm level is changed into another fault alarm level during performance of the ring switch, performing ring switch according to the another fault alarm level.

10. The node apparatus as claimed in claim 7, further comprising:

a part, when, from another node apparatus adjacent on a side reverse to a side on which the ring switch is performed, ring switch request for the own node apparatus is received, isolating said own node apparatus from the ring.

11. The node apparatus as claimed in claim 7, further comprising:

a part, when span switch request higher in the priority than the ring switch is received by the own node apparatus, canceling the ring switch operation of said own node apparatus, and causing the received span switch request to pass through said own node apparatus so as to be transmitted to an adjacent node apparatus.

12. The node apparatus as claimed in claim 7, further comprising:

a part, when span switch is attempted to be performed between the own node apparatus and each

of adjacent node apparatuses on both sides, but the span switch between said own node apparatus and the one adjacent node apparatus cannot be performed so as to be changed into ring switch, comparing the priority between the span switch request for the other adjacent node apparatus and the ring switch request for said one adjacent node apparatus so as to determine whether the span switch or ring switch is to be performed, and sending request to the adjacent node apparatuses on both sides based on the result of the determination.

ABSTRACT OF THE DISCLOSURE

A switching method in a bidirectional line switched ring includes the steps of performing span switch by one node of the ring for getting rid of a fault detected by the one node, changing the span switch into ring switch when the span switch could not be performed normally, and performing the ring switch, and holding the ring switch request as an internal request of the one node when a span switch request, higher in priority than the ring switch, generated in another node is received by the one node.

FIG. 1

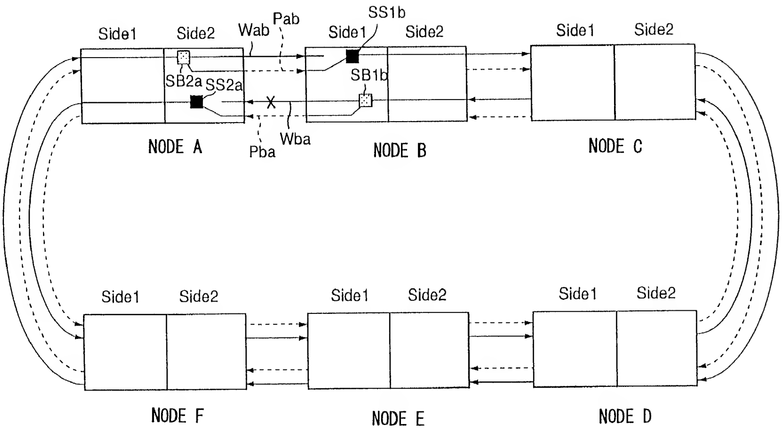
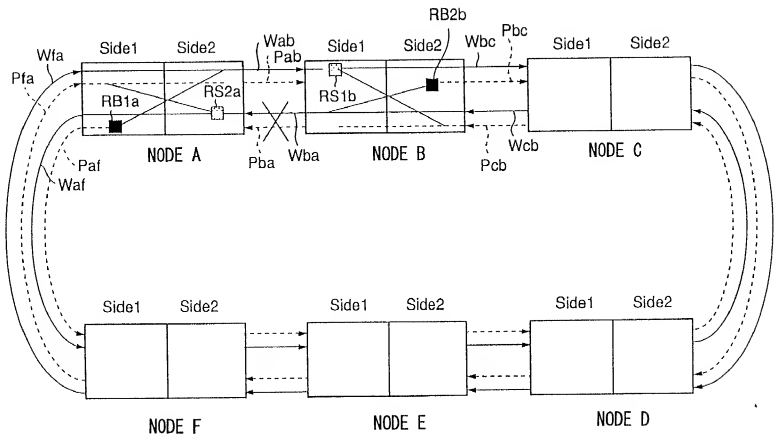

Side1
Side2
Wab
Pab
SS1b
Side1
Side2
Side1
Side2
SB2a
SS2a
SB1b
NODE A
Pba
Wba
NODE B
NODE C
Side1
Side2
Side1
Side2
Side1
Side2
NODE F
NODE E
NODE D

FIG. 2



RB2b
Wab
Pab
Wbc
Pbc
Wfa
Pfa
Side1
Side2
RS2a
RB1a
RS1b
Paf
Waf
Pba
Wba
Wcb
Pcb
NODE A
NODE B
NODE C
NODE D
NODE E
NODE F

FIG. 3

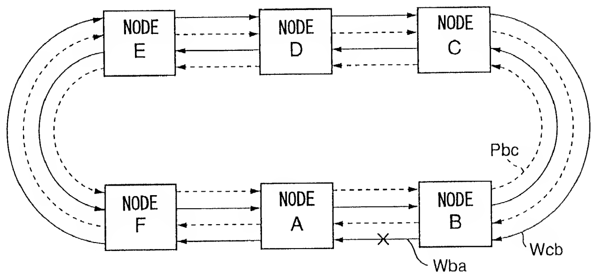
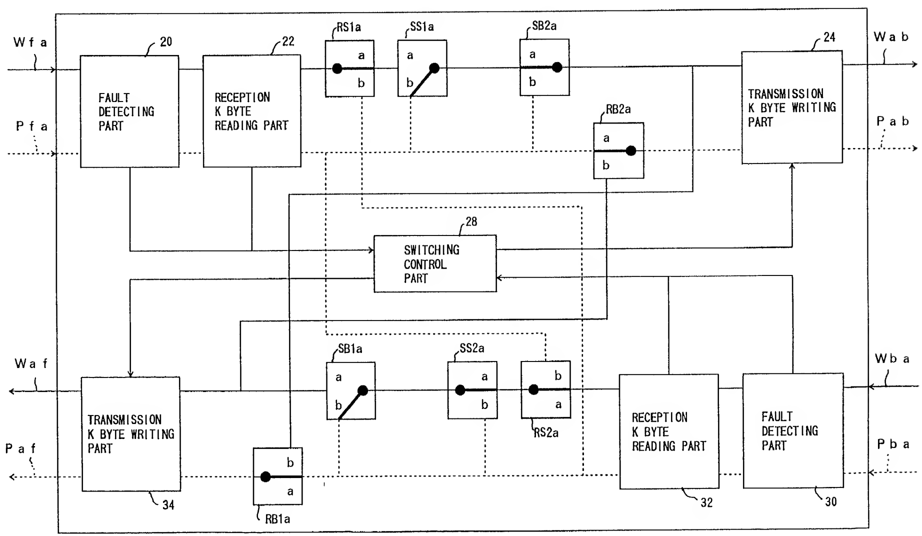
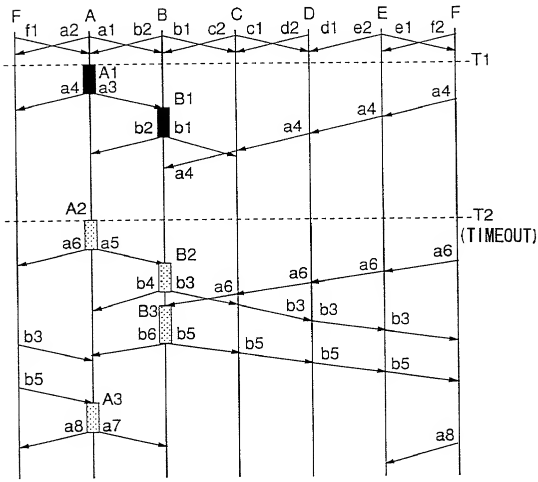


FIG. 4



Wfa
Pfa
20
FAULT DETECTING PART
22
RECEPTION K BYTE READING PART
RS1a
SS1a
SB2a
RB2a
24
TRANSMISSION K BYTE WRITING PART
Wab
Pab
28
SWITCHING CONTROL PART
Waf
Paf
TRANSMISSION K BYTE WRITING PART
34
RB1a
SB1a
SS2a
RS2a
RECEPTION K BYTE READING PART
32
FAULT DETECTING PART
30
Wba
Pba
a
b

FIG. 5



F
A
B
C
D
E
F
f1
a2
a1
b2
b1
c2
c1
d2
d1
e2
e1
f2
T1
A1
a4
a3
B1
a4
a4
b2
b1
a4
a4
A2
T2
(TIMEOUT)
a6
a5
B2
a6
a6
a6
b4
b3
a6
B3
b3
b3
b3
b3
b6
b5
b5
b5
b5
b5
A3
a8
a7
a8

FIG. 6A

SYMBOL	K1 BYTE		K2 BYTE		
	BIT(1-4)	BIT(5-8)	BIT(1-4)	BIT(5)	BIT(6-8)
a 1	N R	B	A	SHORT	IDLE
a 2	N R	F	A	SHORT	IDLE
b 1	N R	C	B	SHORT	IDLE
b 2	N R	A	B	SHORT	IDLE
c 1	N R	D	C	SHORT	IDLE
c 2	N R	B	C	SHORT	IDLE
d 1	N R	E	D	SHORT	IDLE
d 2	N R	C	D	SHORT	IDLE
e 1	N R	F	E	SHORT	IDLE
e 2	N R	D	E	SHORT	IDLE
f 1	N R	A	F	SHORT	IDLE
f 2	N R	E	F	SHORT	IDLE

FIG. 6B

a 3	S F − S	B	A	SHORT	IDLE
a 4	S F − S	B	A	LONG	IDLE
a 5	S F − R	B	A	SHORT	IDLE
a 6	S F − R	B	A	LONG	IDLE
b 3	S F − R	A	B	LONG	IDLE
b 4	R R − R	A	B	SHORT	IDLE
b 5	S F − R	A	B	LONG	Br&Sw
b 6	R R − R	A	B	SHORT	Br&Sw
a 7	S F − R	B	A	SHORT	Br&Sw
a 8	S F − R	B	A	LONG	Br&Sw

FIG. 7

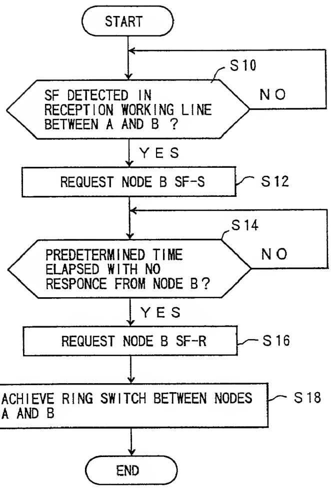

START
SF DETECTED IN RECEPTION WORKING LINE BETWEEN A AND B ?
S10
NO
YES
REQUEST NODE B SF-S
S12
PREDETERMINED TIME ELAPSED WITH NO RESPONCE FROM NODE B ?
S14
NO
YES
REQUEST NODE B SF-R
S16
ACHIEVE RING SWITCH BETWEEN NODES A AND B
S18
END

FIG. 8

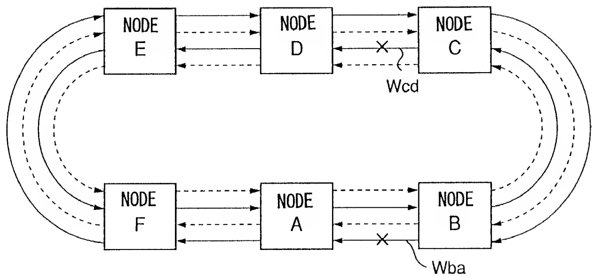


FIG. 9

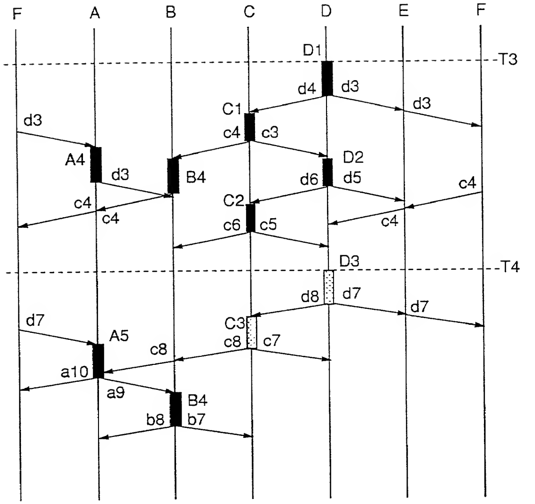

F
A
B
C
D
E
F
D1
T3
d4
d3
d3
C1
d3
c4
c3
A4
d3
B4
D2
d6
d5
c4
C2
c4
c4
c6
c5
c4
D3
T4
d8
d7
d7
d7
C3
A5
c8
c8
c7
a10
a9
B4
b8
b7

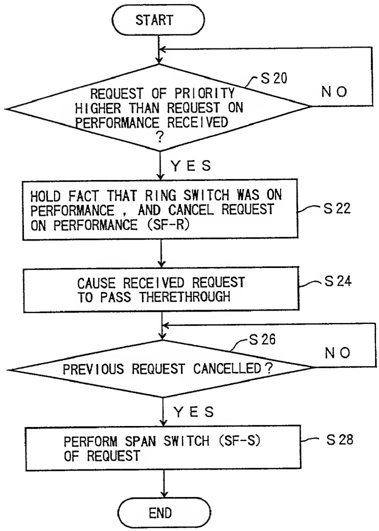
FIG. 10A

SYMBOL	K1 BYTE		K2 BYTE		
	BIT(1-4)	BIT(5-8)	BIT(1-4)	BIT(5)	BIT(6-8)
d 3	S F − S	C	D	LONG	IDLE
d 4	S F − S	C	D	SHORT	IDLE
c 3	R R − S	D	C	SHORT	Br
c 4	S F − S	D	C	LONG	Br
d 5	S F − S	C	D	LONG	Br&Sw
d 6	S F − S	C	D	SHORT	Br&Sw
c 5	R R − S	D	C	SHORT	Br&Sw
c 6	S F − S	D	C	LONG	Br&Sw
d 7	W T R	E	D	LONG	Br&Sw
d 8	W T R	C	D	SHORT	Br&Sw

FIG. 10B

c 7	R R − S	D	C	SHORT	Br&Sw
c 8	W T R	D	C	LONG	Br&Sw
a 9	S F − S	B	A	SHORT	IDLE
a 10	S F − S	B	A	LONG	IDLE
b 7	N R	C	B	SHORT	IDLE
b 8	N R	A	B	SHORT	IDLE

FIG. 11



START
REQUEST OF PRIORITY HIGHER THAN REQUEST ON PERFORMANCE RECEIVED ?
S 20
NO
YES
HOLD FACT THAT RING SWITCH WAS ON PERFORMANCE , AND CANCEL REQUEST ON PERFORMANCE (SF-R)
S 22
CAUSE RECEIVED REQUEST TO PASS THERETHROUGH
S 24
PREVIOUS REQUEST CANCELLED ?
S 26
NO
YES
PERFORM SPAN SWITCH (SF-S) OF REQUEST
S 28
END

FIG. 12

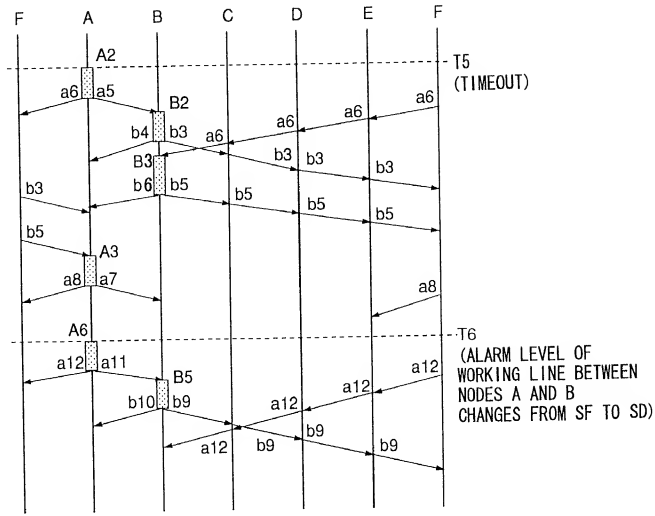

F
A
B
C
D
E
F
A2
T5
(TIMEOUT)
a6
a5
B2
a6
a6
a6
b4
b3
a6
B3
b3
b3
b3
b6
b5
b3
b5
b5
b5
b5
A3
a8
a7
a8
A6
T6
(ALARM LEVEL OF
WORKING LINE BETWEEN
NODES A AND B
CHANGES FROM SF TO SD)
a12
a11
a12
B5
a12
b10
b9
a12
b9
a12
b9
b9

FIG. 13

SYMBOL	K1 BYTE		K2 BYTE		
	BIT(1-4)	BIT(5-8)	BIT(1-4)	BIT(5)	BIT(6-8)
a11	SD-R	B	A	SHORT	Br&Sw
a12	SD-R	B	A	LONG	Br&Sw
b9	SD-R	A	B	SHORT	Br&Sw
b10	RR-R	A	B	LONG	Br&Sw

FIG. 14

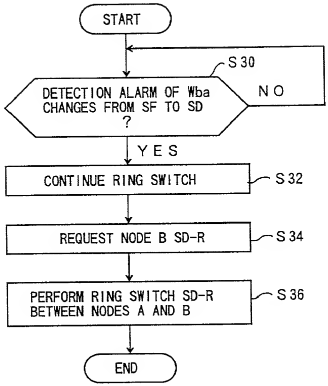

START
S 30
DETECTION ALARM OF Wba CHANGES FROM SF TO SD ?
NO
YES
CONTINUE RING SWITCH
S 32
REQUEST NODE B SD-R
S 34
PERFORM RING SWITCH SD-R BETWEEN NODES A AND B
S 36
END

FIG. 15

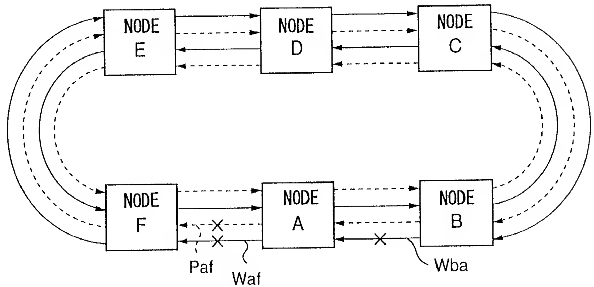


FIG. 16

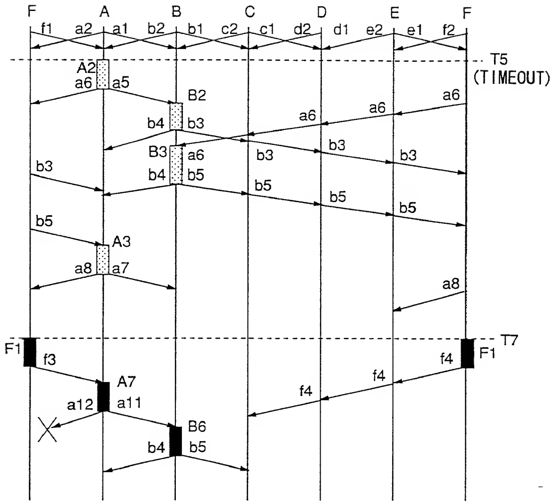

F
A
B
C
D
E
F
f1
a2
a1
b2
b1
c2
c1
d2
d1
e2
e1
f2
T5
(TIMEOUT)
A2
a6
a5
B2
a6
a6
a6
b4
b3
B3
a6
b3
b3
b3
b3
b4
b5
b5
b5
b5
b5
A3
a8
a7
a8
T7
F1
F1
f3
f4
f4
f4
A7
a12
a11
B6
b4
b5

FIG. 17

SYMBOL	K1 BYTE		K2 BYTE		
	BIT(1-4)	BIT(5-8)	BIT(1-4)	BIT(5)	BIT(6-8)
f 3	S F − R	A	F	SHORT	R D I
f 4	S F − R	A	F	LONG	Br&Sw
a 11	S F − R	B	A	SHORT	IDLE
a 12	S F − R	B	A	LONG	IDLE

FIG. 18

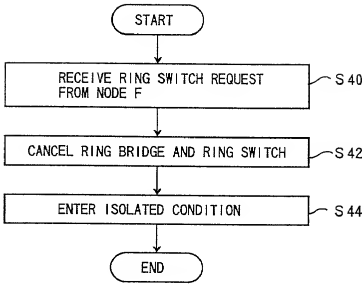

START
RECEIVE RING SWITCH REQUEST FROM NODE F
S 40
CANCEL RING BRIDGE AND RING SWITCH
S 42
ENTER ISOLATED CONDITION
S 44
END

FIG. 19

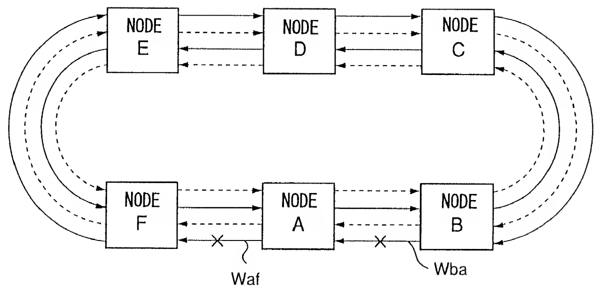
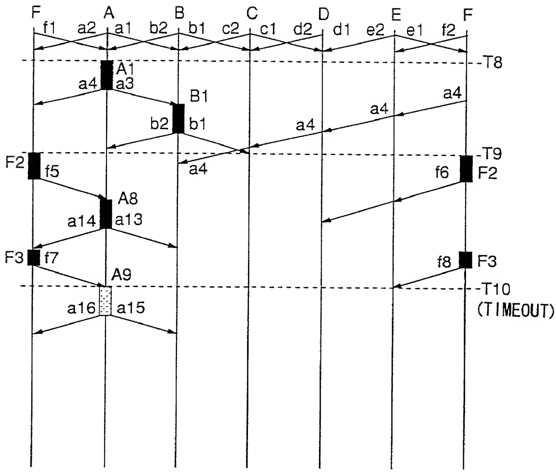


FIG. 20

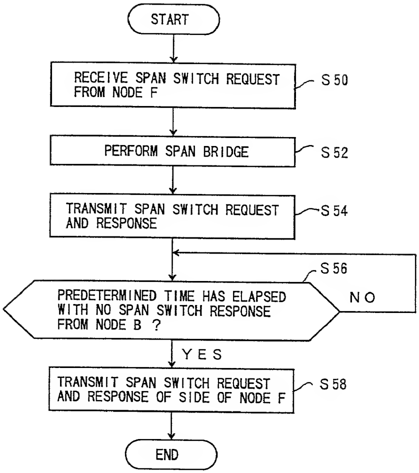


F
A
B
C
D
E
F
f1
a2
a1
b2
b1
c2
c1
d2
d1
e2
e1
f2
T8
A1
a4
a3
B1
a4
a4
b2
b1
a4
T9
F2
f5
a4
f6
F2
A8
a14
a13
F3
f7
f8
F3
A9
T10
(TIMEOUT)
a16
a15

FIG. 21

SYMBOL	K1 BYTE		K2 BYTE		
	BIT(1-4)	BIT(5-8)	BIT(1-4)	BIT(5)	BIT(6-8)
f 5	S F − S	A	F	SHORT	IDLE
f 6	S F − S	A	F	LONG	IDLE
a 13	S F − S	B	A	SHORT	IDLE
a 14	R R − S	F	A	SHORT	Br
f 7	S F − S	A	F	SHORT	Br&Sw
f 8	S F − S	A	F	LONG	Br&Sw
a 15	S F − S	F	A	LONG	Br&Sw
a 16	R R − S	F	A	SHORT	Br&Sw

FIG. 22


START
RECEIVE SPAN SWITCH REQUEST FROM NODE F
S 50
PERFORM SPAN BRIDGE
S 52
TRANSMIT SPAN SWITCH REQUEST AND RESPONSE
S 54
S 56
PREDETERMINED TIME HAS ELAPSED WITH NO SPAN SWITCH RESPONSE FROM NODE B ?
NO
YES
TRANSMIT SPAN SWITCH REQUEST AND RESPONSE OF SIDE OF NODE F
S 58
END

DOCKET NO.: FUJI 17.859

PTO/SB/106 (8-96)
Approved for use through 9/30/98. OMB 0651-0032
Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Declaration and Power of Attorney For Patent Application

特許出願宣言書及び委任状

Japanese Language Declaration

日本語宣言書

下記の氏名の発明者として、私は以下の通り宣言します。

As a below named inventor, I hereby declare that:

私の住所、私書箱、国籍は下記の私の氏名の後に記載された通りです。

My residence, post office address and citizenship are as stated next to my name.

下記の名称の発明に関して請求範囲に記載され、特許出願している発明内容について、私が最初かつ唯一の発明者（下記の氏名が一つの場合）もしくは最初かつ共同発明者であると（下記の名称が複数の場合）信じています。

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

SWITCHING METHOD FOR BIDIRECTIONAL LINE SWITCHED RING AND NODE APPARATUS USED IN THE RING

上記発明の明細書（下記の欄でx印がついていない場合は、本書に添付）は、

the specification of which is attached hereto unless the following box is checked:

☐ __月__日に提出され、米国出願番号または特許協定条約国際出願番号を__________とし、（該当する場合）__________に訂正されました。

☐ was filed on ____________________ as United States Application Number or PCT International Application Number _______________ and was amended on _______________ (if applicable).

私は、特許請求範囲を含む上記訂正後の明細書を検討し、内容を理解していることをここに表明します。

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

私は、連邦規則法典第３７編第１条５６項に定義されるとおり、特許資格の有無について重要な情報を開示する義務があることを認めます。

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

Japanese Language Declaration
(日本語宣言書)

私は、米国法典第35編119条(a)-(d)項又は365条(b)項に基き下記の、米国以外の国の少なくとも一ヵ国を指定している特許協力条約365(a)項に基ずく国際出願、又は外国での特許出願もしくは発明者証の出願についての外国優先権をここに主張するとともに、優先権を主張している、本出願の前に出願された特許または発明者証の外国出願を以下に、枠内をマークすることで、示しています。

I hereby claim foreign priority under Title 35, United States Code, Section 119 (a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s)
外国での先行出願

(Number) (番号)	(Country) (国名)	(Day/Month/Year Filed) (出願年月日)	Priority Not Claimed 優先権主張なし
Pat. Appln. No.11-371615	Japan	27/December/1999	☐
			☐

私は、第35編米国法典119条(e)項に基いて下記の米国特許出願規定に記載された権利をここに主張いたします。

I hereby claim the benefit under Title 35, United States Code, Section 119(e) of any United States provisional application(s) listed below.

(Application No.) (出願番号)	(Filing Date) (出願日)	(Application No.) (出願番号)	(Filing Date) (出願日)

私は、下記の米国法典第35編120条に基いて下記の米国特許出願に記載された権利、又は米国を指定している特許協力条約365条(c)に基ずく権利をここに主張します。また、本出願の各請求範囲の内容が米国法典第35編112条第1項又は特許協力条約で規定された方法で先行する米国特許出願に開示されていない限り、その先行米国出願書提出日以降で本出願書の日本国内または特許協力条約国際提出日までの期間中に入手された、連邦規則法典第37編1条56項で定義された特許資格の有無に関する重要な情報について開示義務があることを認識しています。

I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s), or 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code Section 112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of application.

(Application No.) (出願番号)	(Filing Date) (出願日)	(Status: Patented, Pending, Abandoned) (現況：特許許可済、係属中、放棄済)

私は、私自身の知識に基ずいて本宣言書中で私が行なう表明が真実であり、かつ私の入手した情報と私の信じるところに基ずく表明が全て真実であると信じていること、さらに故意になされた虚偽の表明及びそれと同等の行為は米国法典第18編第1001条に基ずき、罰金または拘禁、もしくはその両方により処罰されること、そしてそのような故意による虚偽の声明を行なえば、出願した、又は既に許可された特許の有効性が失われることを認識し、よってここに上記のごとく宣誓を致します。

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Japanese Language Declaration
(日本語宣言書)

委任状： 私は下記の発明者として、本出願に関する一切の手続きを米特許商標局に対して遂行する弁理士または代理人として、下記の者を指名いたします。（弁護士、または代理人の氏名及び登録番号を明記のこと）	**POWER OF ATTORNEY:** As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith *(list name and registration number)*
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第五共同発明者		Full name of fifth joint inventor, if any	
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第六共同発明者		Full name of sixth joint inventor, if any	
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(第七以降の共同発明者についても同様に記載し、署名をすること)

(Supply similar information and signature for seventh and subsequent joint inventors.)

THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Application of: **Takashi HONDA et al.**

Filed : **Concurrently herewith**

For : **SWITCHING METHOD FOR BIDIRECTIONAL LINE SWITCHED RING AND NODE APPARATUS USED IN THE RING**

Serial No. : **Concurrently herewith**

October 11, 2000

Assistant Commissioner of Patents
Washington, D.C. 20231

SUB-POWER OF ATTORNEY

S I R:

I, Samson Helfgott, Reg. No. 23,072 attorney of record herein, do hereby grant a sub-power of attorney to Linda S. Chan, Reg. No. 42,400, Harris A. Wolin, Reg. No. 39,432 and Brian S. Myers, Reg. No. 46,947 to act and sign in my behalf in the above-referenced application.

Respectfully submitted,

Samson Helfgott
Reg.No 23,072

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